CCUS potential in Vietnam

Decarbonisation can bring opportunities for industrial gases

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A transition from rural life to a more industrialised ecomomy is firmly underway in Vietnam

Vietnam is a Southeast Asian country known for its stunningly beautiful landscape, Buddhist pagodas and buzzing cities. It is highly populated, with almost 100 million inhabitants. Having suffered years of high poverty rates, it is now a middle-income country with annual GDP growth of around 7%. This pace of development is likely to continue, which means that consumer demand for power and investment in heavy industry will increase, consequently leading to higher annual carbon dioxide (CO_2) emissions.

Vietnam's energy development plans include significant increases in natural gas and coal-fired power generation to underpin the expected economic expansion. To mitigate the impact on climate change, Carbon capture and storage (CCS) can be implemented in Vietnam to curtail the growth of CO_2 emissions and ultimately lead to a climate neutral economy.

Vietnam has ideal sub-surface geological conditions for underground CO_2 storage to enable massive CCS schemes. Furthermore, Vietnam's proximity to highly industrialised countries in North Asia, such as Japan and South Korea, which have very limited potential for CCS, makes it a potentially attractive location as an Asian regional CCS hub.

CO_2 emissions sources in Vietnam

Currently, the main sources of CO_2 emissions in Vietnam are thermal power stations, including coal, gas, and fuel oil-fired plants. Annual CO_2 emissions in Vietnam have increased from 13 million tonnes in 1990, to 253 million tonnes in 2018. It is expected that this could increase to 830 million tonnes in 2030 and the growth is largely due to the target of 44 GW of power generation in 2030 to meet the anticipated energy demand.

Much of this will be met by additional coal and gas-fired power stations, and several LNG terminals are planned to fire the gas turbines as indigenous gas reserves dwindle. Vietnam is likely to join Japan, China, and South Korea as a major market for LNG.

Due to recent growth in iron and steel production in Vietnam, it is now the largest crude steel producer in ASEAN. Vietnam's export of iron and steel in the first quarter of 2021 has seen 6.5% growth compared to the first quarter in 2020, and annual export revenues from these products are now close to $2bn. The EU-Vietnam free trade agreement has boosted production, with leading Vietnamese producers including Hoa Phat Group and Hoa Sen Group.

Recently, cement consumption has also significantly increased in Vietnam, resulting in an increase in the number of cement plants operating in the country. This is driven by new infrastructure construction and the booming property sector. The largest cement producer is Vietnam National Cement Corporation (VICEM). In 2019, Vietnam was ranked at fourth in global CO_2 emissions from cement making. Only China, India and Indonesia emitted more CO_2 from this sector.

Both cement and steel production can utilise oxygen for a diverse range of applications. In iron and steelmaking oxygen is required for blast furnaces and lancing to reduce the carbon content of steel. Oxygen enrichment is common for process intensification, or to enable a high level of co-combustion of humid waste material in cement kilns.

In support of the Paris Agreement, Vietnam has committed to Nationally Determined Contributions (NDCs) for greenhouse gas emissions reduction. Decarbonisation of energy and industrial processes are in focus and the policy has explicit references to blast furnace slag to replace cement clinker and GHG emissions reduction in cement production. CCS is therefore set to play an increasingly important role.

CO_2 utilisation potential in Vietnam

Captured CO_2 can be injected into depleted oil fields to enhance oil recovery and be pumped into greenhouses to boost plant growth. Additional CO_2 utilisation applications include, pH control of water, carbonating beverages, food packaging, welding, food freezing and with great relevance to combatting the coronavirus - dry ice production for vaccine distribution.

Carbon dioxide utilisation, therefore, has huge potential and there is a pressing need for CO_2 distribution and applications development from industrial gases companies in Vietnam. They would have the crucial responsibility of taking the captured and liquified carbon to end-users. Furthermore, innovating new sustainable and economically beneficial applications for the additional CO_2 utilisation would also be a valuable contribution that

industrial gases companies can make to mitigate climate change.

In the future, there will undoubtedly be more captured CO_2 than the world needs from the current utilisation applications portfolio. Industrial gases operators could play a vital role in distributing CO_2 on ships, trucks, or trains from an emissions source to a location where it can be injected underground for permanent storage. Bulk liquid CO_2 logistics in support of CCS is therefore a major area of potential business development for industrial gases operators.

Global learnings can ensure effective deployment of CCS in Vietnam

From a technical point of view, Vietnam has an attractive geological structure for underground CO_2 storage. Based on conservative estimations, 12 billion tonnes of CO_2 could be injected into sub-surface storage locations, the majority of which would be in saline aquifers and additional tonnages in depleted oil and gas fields.

The Utsira saline aquifer has been used successfully for permanent underground CO_2 storage by Equinor, previously Statoil, at the Sleipner West gas field in the Norwegian sector of the North Sea for over 20 years. Equinor and other oil and gas majors are currently making plans to develop CCS schemes in the UK sector of the Utsira geological formation.

One of the largest CCS projects in development globally, is the Gorgon project in Western Australia. It has needed to overcome several challenges regarding equipment specifications to ensure effective brine removal from the saline aquifer that is being used for CO_2 storage. The experience and lessons from Gorgon and the North Sea can be applied to subsequent CCS projects in Vietnam and other high potential CCS regions of the world.

The economics of CCS or CCUS

CCS can be integrated into the energy sector infrastructure to make it more economical. The combination of natural gas reforming with CCS to make blue hydrogen is one possible example, gasification of coal with integrated CCS to make purple hydrogen is an alternative.

One way to improve the economics of CCS is to combine it with EOR (enhanced oil recovery), in which case we must refer to carbon capture, utilisation and storage, or CCUS. This would mean that carbon capture, transportation and storage costs will be partly recovered by enhanced oil production from depleted oil fields.

No CCS pilot has yet taken place in Vietnam, but the Cuu Long Basin in the southern part of the country could be an ideal location for CCUS. Captured CO_2 could be transported via onshore pipeline, offshore pipeline or ship from the CO_2 emitting source to the offshore field and the CCUS, along with EOR, could be implemented in depleted oil fields in Cuu Long Basin. To put some numbers to the scale of the CCUS potential in the Cuu Long basin, in one oil field the annual CO_2 injection and storage capacity would be 4.6 million tonnes which would increase oil recovery by 45,000 bbl/day.

The amount of sequestered CO_2 is large, but it is still only a small fraction of Vietnam's national CO_2 emissions. This demonstrates the need for multiple CCUS schemes and highlights the imperative to think beyond CCUS for EOR towards projects that are dedicated to CCS in saline aquifers.

The estimated CCS costs in Vietnam are between \$50-65/tonne of CO_2. As with other schemes, this typically breaks out to be 85% related to CO_2 capture, 4% for transportation and 11% for permanent underground storage. High carbon prices would encourage private sector investment in CCS and a CO_2 emissions reduction. When considering the revenue generation associated with EOR, CCUS could be an economically viable option for decarbonisation in Vietnam if the carbon dioxide emissions cost is around \$25/tonne of CO_2.

Policy initiatives to stimulate CCS or CCUS in Vietnam

Although the technical evaluation shows the high potential of CCS and CCUS in Vietnam, regulatory changes are required to catalyse development and deployment of this technology.

Whilst energy policy is developing and the use of renewables is increasing, currently, there is no clear plan to reduce CO_2 emissions from the installed base of fossil fuel plants and new fossil fired capacity is planned.

In the power sector, EVN (Electricity of Vietnam) could be a highly influential stakeholder for CCUS. EVN controls power generation and the power grid in Vietnam and its ambition and vision impacts CO_2 emissions and the potential for post-combustion CCUS deployment.

Petro Vietnam (PVN) is also a key stakeholder, with CO_2 emissions from SMRs (steam methane reformers), refineries and power plants. Additionally, PVN could hold the key to unlock the potential for underground CO_2 storage. Its upstream oil and gas expertise would be relevant to CO_2 transmission in pipelines and is essential to understand the sub-surface geology for permanent underground storage of CO_2.

The government of Vietnam can also play a catalytic role with carbon taxes, subsidies for demonstration projects and R&D support to enable change and to motivate the industry to decarbonise. A holistic review of energy policy, to focus on low carbon solutions, including CCS for blue hydrogen production from natural gas would also unlock the potential for CCS. gw